

pound to decompose such that the fragments are easily volatilized, and essentially ablate from the surface of the exposed resist. Finally, the resist can be comprised of a mixture of one or more of the above identified resist materials such a mixture of a polymer and conjugated molecules.

**[0027]** Illustrative of one of the advantages of the present process is the comparison in FIG. 4 showing structures obtained using a wet development process with xylene, and the dry development process by laser according to one aspect of this invention. As observed in the upper photograph, wall/feature collapse can easily be seen, while no such wall collapse is evident according to the instant dry development process.

**[0028]** As heretofore noted, e-beams have been used with or without masks to write very fine patterns onto a resist layer. Where the patterns are to be serially drawn, after a long exposure for a time  $t_1$ , the resist can be subject to prior art wet or dry processes used to address pattern collapse. With e-beam exposure alone, however, unacceptably long exposure times in the order, for example of 0.5 years would be required to write a 300 mm wafer with a dose of 20 mC/cm<sup>2</sup>, at 1 nA current. Thus, today, as a practical matter only small areas are exposed to make a mask and these areas are replicated over and over.

**[0029]** By use of the lasers and resist materials according to the invention, the efficiency of the process is greatly improved, even when using e-beam exposure as an initial step. Thus, in an alternative embodiment, combining e-beam exposure with exposure of the resist layer to visible light, the resist coated substrate can be first subject to high resolution e-beam exposure for a relatively short period of time  $t_2$ , to thus partially expose the resist, where  $t_2 < t_1$ . The resist can then be subject to further exposure to light, in one embodiment a laser light for an additional time  $t_3$ , using the same mask, to finish the exposure.

**[0030]** As a further advantage such as in the case of calixarenes, we have found that the modulus of the calixarene material can be increased, to thus facilitate more traditional wet development using conventional approaches. Using such modified calixarenes, after an exposure to light energy for a time  $t_3$ , one can follow a wet development process. Alternatively, to continue with a dry process, the exposure can be carried out for an additional amount of time  $t_4$  (for a total exposure time of  $t_3 + t_4$ ), whereby that the calixarene is further converted such that it becomes volatile and in effect sublimates/ablates in those areas of exposure.

**[0031]** In addition to being able to process the wafer without encountering pattern collapse, the efficiency of the process is increased due to the reduction in total processing time. Thus, the amount of exposure time  $t_{2(e-beam)} + t_3 + t_4$  is still substantially less than  $t_1$ . By way of example,  $t_1$  might equal 12 hours, while  $t_2 + t_3 + t_4$  might collectively be 7 hours. Further time savings can also be realized by reducing laser exposure times by simply increasing the power of the laser beam used for the exposures.

**[0032]** The lasers used in this process are generally low power, continuous wavelength lasers in the UV/visible light range. In experiments performed, we have used a 532 nm CW laser with a maximum power of 30 mW, and a power density of between 1 to 14 megawatts (MW) per cm<sup>2</sup>. Particularly useful are lasers in the visible light range where the absorption differences between exposed and non exposed areas results in the high volatility contrasts. Other visible light wavelength lasers would be expected to perform just as well.

**[0033]** This invention has been described herein in considerable detail to provide those skilled in the art with information relevant to apply the novel principles and to construct and use such specialized components as are required. However, it is to be understood that the invention can be carried out by different equipment, materials and devices, and that various modifications, both as to the equipment and operating procedures, can be accomplished without departing from the scope of the invention itself.

We claim:

1. A process for lithographic development comprising:
  - (i) depositing a layer of a resist material on a substrate;
  - (ii) exposing a region of the resist material to a source of high-resolution radiation;
  - (iii) exposing the resist material to a light source wherein the region exposed to the high-resolution radiation is volatilized.
2. The process of claim 1 wherein the light source is in the visible light range.
3. The process of claim 1 wherein the light source is a laser light source.
4. The process of claim 3 wherein the laser light source is a 532 nm wavelength laser.
5. The process of claim 4 wherein the laser light source is operated at a power density of between 1 MW/cm<sup>2</sup> and 14 MW/cm<sup>2</sup>.
6. The process of claim 1 wherein the source of high-resolution radiation is an electron beam.
7. The process of claim 1 wherein the source of high-resolution radiation is extreme ultra violet light.
8. A process for lithographic exposure and development comprising:
  - (i) depositing a layer of a resist material on a substrate;
  - (ii) exposing a region of the resist material to a source of high-resolution radiation for a limited period of time to only partially change the solubility characteristics of the resist;
  - (iii) further exposing the resist material to a light source to continue the chemical modification initiated by the high resolution source to complete the change in solubility; and thereafter,
  - (iv) wet developing the resist material to reveal the high resolution pattern created in the preceding steps.
9. The process of claim 8 wherein the light source is a laser light source.
10. The process of claim 9 wherein the laser light source is operated at a power density of between 1 MW/cm<sup>2</sup> and 14 MW/cm<sup>2</sup>.
11. The process of claim 1 wherein the region exposed to the high-resolution radiation is volatilized upon exposure to the said light source.
12. The process of claim 1, wherein the resist material comprises conjugated groups.
13. The process of claim 12 wherein the conjugated resist material comprises aromatic groups.
14. The process of claim 1 wherein the resist material comprises a calixarene.
15. The process of claim 14, wherein the resist material is a calixarene.
16. The process of claim 14, wherein the resist is substituted with a group selected from the group consisting of halo, cyano, and nitro.
17. The process of claim 1 wherein the resist material can be a mixture of materials.